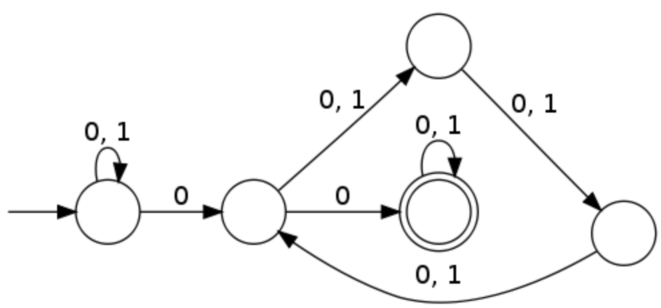
Written Assignment I
Due Thursday, October 7, 2010 at 5pm

This assignment asks you to prepare written answers to questions on regular languages, finite automata, and lexical analysis. Each of the questions has a short answer. You may discuss this assignment with other students and work on the problems together. However, your write-up should be your own individual work. Written assignments can be turned in at the start of lecture. Alternatively, assignments can be turned in at Professor Aiken's office in Gates 411, or submitted electronically in PDF format by following the electronic submission instructions at `http://www.stanford.edu/class/cs143/policies/submit.html`, by 5:00 PM on the due date.

1. Write regular expressions for the following languages over the alphabet $\Sigma = \{a, b\}$:
   (a) All strings that do not end with aa.
   (b) All strings that contain an even number of b's.
   (c) All strings which do not contain the substring ba.
2. Draw DFAs for each of the languages from question 1. None of your DFAs may contain more than 4 states.
3. Consider the following non-deterministic finite automaton (NFA) over the alphabet $\Sigma = \{0, 1\}$.

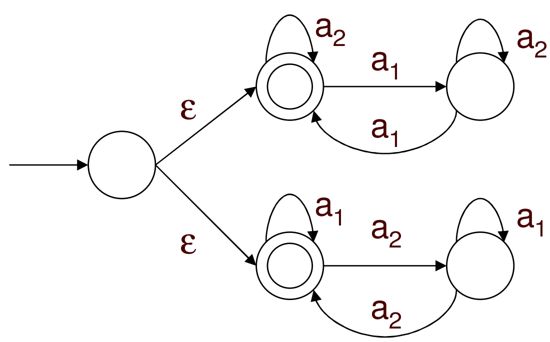


   Give a one-sentence description of the language recognized by the NFA. Write a regular expression for this language.

4. Let $\Sigma_m = \{a_1, \ldots, a_m\}$ be an alphabet containing m elements, for some integer $m \geq 1$. Let L_m be the following language:

   All strings in which at least one a_i occurs an even number of times (not necessarily consecutively), where $1 \leq i \leq m$.

   The following figure shows an NFA for the language L_2.



   Construct a DFA for the language L_2 that has at most 6 states. Also construct an NFA for the language L_3 that has at most 7 states.

   Aside: Non-deterministic finite automata (NFAs) are no more powerful than DFAs in terms of the languages that they can describe. However, NFAs can be exponentially more succinct than DFAs, as this problem demonstrates. For the language L_m, there exists an NFA of size at most $2m+1$ while any DFA must have size at least 2^m. Note that the DFA for the language L_3 is not as easy to construct as the NFA for the language L_3.

5. Consider the string

   `abaabaabababbaaabaab`

   and its tokenization

   `abaa ba ababa bba aa ba a b`

   Give a flex specification with the minimum number of rules that produces this tokenization. Each flex rule should be as simple as possible as well. You may not use regular expression union (i.e., $R1 + R2$) in your solution. Do not give any actions; just assume that the rule returns the string that it matches.